

**STANDARD****Class 0 Motion Imagery, Audio and  
Metadata over SDI****21 June 2018**

## 1 Scope

This standard provides guidance for carrying Class 0 Motion Imagery and KLV metadata over Serial Digital Interface (SDI).

This standard provides for inclusion of Absolute Time as either a microsecond-resolution Precision Time Stamp, or a nanosecond-resolution Nano Precision Time Stamp as defined in MISB ST 0603.

This standard defines a Precision Time Stamp Pack, which is a KLV construct consisting of a Time Status byte and a Precision Time Stamp. To support the Nano Precision Time Stamp, this standard defines a Nano Precision Time Stamp Pack, which is a KLV construct consisting of a Time Status byte and a Nano Precision Time Stamp. In addition, the placement of these timestamp KLV packs and other KLV metadata within the ancillary (ANC) data space allocated in SMPTE-defined image formats is specified.

The standard identifies the ANC packet format for encoding KLV metadata into the ancillary data space.

SMPTE standards for inserting audio into SDI are indicated. In addition, reserved space for mission audio is indicated.

Finally, informative guidance on data capacities for various SDI standards is provided.

## 2 References

- [1] MISB ST 1603.2 Time Transfer Pack, Oct 2017.
- [2] MISB ST 0603.5 MISP Time System and Timestamps, Oct 2017.
- [3] MISB MISP-2018.3 Motion Imagery Standards Profile, Jun 2018.
- [4] MISB ST 0807.22 MISB KLV Metadata Registry, Jun 2018.
- [5] SMPTE RP 168:2009 Definition of Vertical Interval Switching Point for Synchronous Video Switching.
- [6] SMPTE RP 214:2002 Packing KLV Encoded Metadata and Data Essence into SMPTE 291M Ancillary Data Packets.
- [7] SMPTE ST 291-1:2011 Television - Ancillary Data Packet and Space Formatting.
- [8] SMPTE ST 12-2:2014 Television - Transmission of Time Code in the Ancillary Space.

- [9] SMPTE ST 424:2012 3 Gb/s Signal/Data Serial Interface.
- [10] SMPTE ST 425-1:2017 Source Image Format and Ancillary Data Mapping for the 3 Gb/s Serial Interface.
- [11] SMPTE ST 352:2013 Television - Video Payload Identification for Digital Interfaces.
- [12] SMPTE ST 299-1:2009 Television - 24-Bit Digital Audio Format for SMPTE 292 Bit-Serial Interface.
- [13] SMPTE ST 299-2:2010 Television - Extension of the 24-Bit Digital Audio Format to 32 Channels for 3 Gb/s Bit-Serial Interfaces.
- [14] SMPTE ST 355:2001 Television - Format for Non-PCM Audio and Data in AES3 - KLV Data Type.
- [15] SMPTE ST 337:2015 Television - Format for Non-PCM Audio and Data in an AES3 Serial Digital Audio Interface.
- [16] SMPTE ST 339:2015 Television - Format for Non-PCM Audio and Data in AES3 - Generic Data Types.
- [17] SMPTE ST 267:1995 Television - Bit-Parallel Digital Interface - Component Video Signal 4:2:2 16x9 Aspect Ratio.
- [18] SMPTE ST 294:2001 Television - 720x483 Active Line at 59.94-Hz Progressive Scan Production –Bit-Serial Interfaces.
- [19] SMPTE ST 259:2008 Television - SDTV Digital Signal/Data - Serial Digital Interface.
- [20] SMPTE ST 293:2003 Television - 720x483 Active Line at 59.94-Hz Progressive Scan Production – Digital Representation.
- [21] SMPTE ST 349:2001 Television - Transport of Alternate Source Image Formats though SMPTE 292M.
- [22] SMPTE ST 292-1:2018 1.5 Gb/s Signal/Data Serial Interface.
- [23] ITU-R BT.1358-1 (09/2007) Studio Parameters of 625 and 525 Line Progressive Television.
- [24] SMPTE ST 296:2012 1280x720 Progressive Image 4:2:2 and 4:4:4 Sample Structure - Analog and Digital Representation and Analog Interface.
- [25] SMPTE ST 274:2008 Television - 1920x1080 Image Sample Structure, Digital Representation and Digital Timing Reference Sequence for Multiple Picture Rates.
- [26] SMPTE ST 425-5:2015 Image Format and Ancillary Data Mapping for the Quad Link 3 Gb/s Serial Interface.
- [27] SMPTE 425-3:2015 Image Format and Ancillary Data Mapping for the Dual Link 3 Gb/s Serial Interface.
- [28] SMPTE ST 2081-10:2018 2160-Line and 1080-Line Source Image and Ancillary Data Mapping for Single-Link 6G-SDI.
- [29] SMPTE ST 2081-1:2015 6 Gb/s Signal/Data Serial Interface - Electrical.
- [30] SMPTE ST 2081-11:2016 2160-Line Source Image and Ancillary Data Mapping for Dual-Link 6G-SDI.
- [31] SMPTE 2081-12:2016 4320-Line and 2160-Line Source Image and Ancillary Data Mapping for Quad-Link 6G-SDI.

- [32] SMPTE ST 2082-10:2018 2160-Line Source Image and Ancillary Data Mapping for 12G-SDI.
- [33] SMPTE 2082-1:2015 12 Gb/s Signal/Data Serial Interface – Electrical.
- [34] SMPTE ST 2082-12:2016 4320-Line and 2160-Line Source Image and Ancillary Data Mapping for Quad-Link 12G-SDI.
- [35] SMPTE ST 2082-11:2016 4320-Line and 2160-Line Source Image and Ancillary Data Mapping for Dual-Link 12G-SDI.
- [36] SMPTE ST 435-1:2012 10 Gb/s Serial/Data Interface - Part 1: Basic Stream Distribution.
- [37] SMPTE ST 435-2:2012 10 Gb/s Serial Signal/Data Interface - Part 2: 10.692 Gb/s Stream - Basic Stream Data Mapping.
- [38] MISB ST 0403.3 Digital Representation and Source Interface Formats for Infrared Motion Imagery Mapped into 1280x720 format Bit-Serial Digital Interface, Jun 2015.

### 3 Revision History

Revision	Date	Summary of Changes
0605.9	6/21/2018	<ul style="list-style-type: none"> <li>• Added Section 11, which is material moved from MISP-2018.2. This consolidates related information and adds req ST 0605.9-27; added content from ST 0605.8 Appendix C and updated Table 4 for HD/UHD-1/UHD-2</li> <li>• Updated references [3], [4], [10], [22], [28]; added references [29], [31] through [38]</li> <li>• Removed unnecessary references from req's -16, -24, -26</li> <li>• Added recommendation in Section 10.5 for metadata carried within an audio channel</li> <li>• Deleted prior Appendix B and Appendix C; moved prior Appendix D content to new Appendix B</li> </ul>

### 4 Acronyms

<b>AFD</b>	Ancillary Data Flag
<b>ANC</b>	Ancillary Data Space
<b>DC</b>	Data Count
<b>DID</b>	Data ID
<b>ED</b>	Enhanced Definition
<b>HANC</b>	Horizontal Ancillary Data Space
<b>HD</b>	High Definition
<b>KLK</b>	Key Length Value
<b>MID</b>	Message ID
<b>MISB</b>	Motion Imagery Standards Board
<b>MISP</b>	Motion Imagery Standards Profile
<b>PCM</b>	Pulse Code Modulation
<b>PSC</b>	Packet Sequence Count

<b>SD</b>	Standard Definition
<b>SDI</b>	Serial Digital Interface
<b>SDID</b>	Secondary Data ID
<b>SMPTE</b>	Society of Motion Picture and Television Engineers
<b>TRS</b>	Timing Reference Signal
<b>UDW</b>	User Data Word
<b>UHD</b>	Ultra-High Definition
<b>VANC</b>	Vertical Ancillary Data Space

## 5 Definitions

<b>3G-SDI</b>	2.97 Giga-bits per second serial digital interface
<b>6G-SDI</b>	5.94 Giga-bits per second serial digital interface
<b>12G-SDI</b>	11.88 Giga-bits per second serial digital interface
<b>480p</b>	Line-progressive Enhanced Definition (ED) format of the 525-line Standard Definition (SD) system
<b>576p</b>	Line-progressive Enhanced Definition (ED) format of the 625-line Standard Definition (SD) system
<b>720p</b>	High Definition (HD) 1280 x 720 format, progressive scan
<b>1080p</b>	High Definition (HD) 1920 x 1080 format, progressive scan
<b>2160p</b>	Ultra-High Definition (UHD-1) 3840 x 2160 format, progressive scan
<b>4320p</b>	Ultra-High Definition (UHD-2) 7680 x 4320 format, progressive scan

## 6 Introduction

**Serial Digital Interface (SDI)** – developed by SMPTE – is a family of interfaces standardized to accommodate various non-compressed image formats. The SMPTE suite of SDI standards provides the physical interface, timing, encoding, payload and image formats for digital video. The ANC packet developed by SMPTE is designed to encapsulate – among other data types – metadata and audio for transport over SDI within the non-image data space of an image. Two non-image data spaces are defined: the HANC, or horizontal ANC data space, which corresponds to the horizontal blanking interval, and the VANC, or vertical ANC data space, which corresponds to the vertical blanking interval. Both the VANC and HANC are available on a per-frame basis, affording non-image data to be registered to a specific frame in Motion Imagery. This facilitates inserting frame-accurate timestamps and other metadata into non-compressed Class 0 Motion Imagery.

This document assumes use of image sampling formats prescribed by SMPTE for the commercial broadcast industry, specified as an active image area surrounded by vertical and horizontal non-image blanking regions. Within these regions non-image data can be placed, and a specific image sampling format defines the quantity of space available. Data is encapsulated in ANC packets, which affords a generic wrapper for various types of data. The ANC packet provides a natural carrier for non-image data across a Serial Digital Interface.

This document provides guidance on encoding KLV metadata into ANC packets for carriage within the VANC of Class 0 Motion Imagery (non-compressed), specifically to include, either a Precision Time Stamp or a Nano Precision Time Stamp, a Commercial Time Stamp, and other metadata all encoded as KLV (Key Length Value). Introduced in MISB ST 1603 [1] is a Time Quality Local Set to qualify the relationship between a receptor clock and its reference clock with status information. The Time Transfer Local Set provides far greater information than the Time Status as defined in MISB ST 0603 [2], and is recommended for inclusion if needed in applications.

The HANC, which is generally reserved for carrying audio, can optionally be used for additional metadata once the VANC is exhausted.

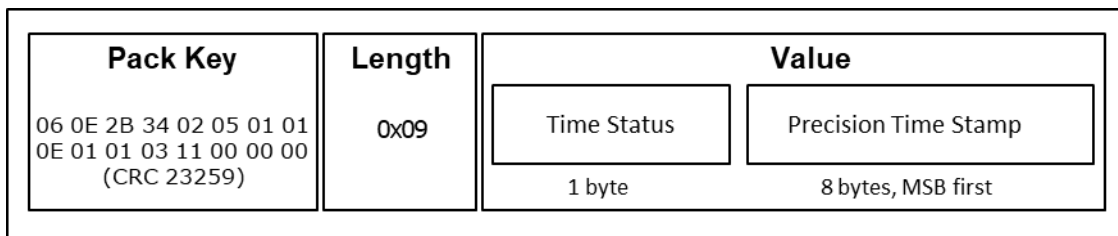
## 7 Timestamps based on Absolute Time

The MISP [3] mandates all Motion Imagery contain a timestamp which is based on Absolute Time governed by the MISP Time System defined in MISB ST 0603. Two KLV pack constructs provide for either a microsecond resolution (Precision Time Stamp) or a nanosecond resolution (Nano Precision Time Stamp) count of Absolute Time. Application requirements for time resolution will determine which timestamp to use.

The MISP also mandates only one type of timestamp is allowed within an instantiation of Motion Imagery. This will prevent confusion as to which timestamp is valid.

## 8 Precision Time Stamp Pack

The construction of the Precision Time Stamp Pack (shown in Figure 1) includes a Pack Key, its Length and a Value, where the timestamp information is encoded.



**Figure 1: Precision Time Stamp Pack**

The Pack key for the Precision Time Stamp is registered in MISB ST 0807 [4] as:

06.0E.2B.34.02.05.01.01.0E.01.01.03.11.00.00.00 (CRC 23259)

The Length of the pack is 0x09 (9 bytes).

The Value in the pack contains two subfields:

- 1) A one-byte Time Status, which indicates the state of the source time reference (as defined in MISB ST 0603).
- 2) A uint64 (8-byte) Precision Time Stamp (as defined in MISB ST 0603).

## 8.1 Time Status

The Time Status provides information about the timing source reference. See MISB ST 0603 for the definition of this value.

## 8.2 Precision Time Stamp

The Precision Time Stamp is a microsecond-resolution, 8-byte value as specified in MISB ST 0603. The Precision Time Stamp follows the Time Status value in the pack. Table 1 shows the byte ordering of the Precision Time Stamp, where Byte 1 is the most significant byte.

**Table 1: Byte Assignment for 64-bit Precision Time Stamp**

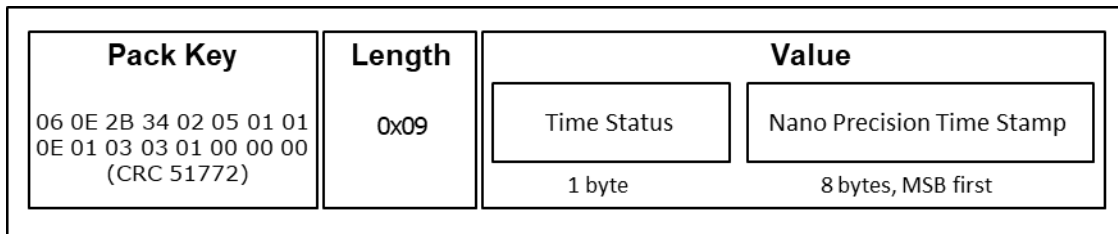
<b>Bytes 1, 2</b>	Byte 1 and 2 (Most significant bytes) of Precision Time Stamp
<b>Bytes 3, 4</b>	Byte 3 and 4 of Precision Time Stamp
<b>Bytes 5, 6</b>	Byte 5 and 6 of Precision Time Stamp
<b>Bytes 7, 8</b>	Byte 7 and 8 (Least significant bytes) of Precision Time Stamp

The following requirements define the construction rules for the Precision Time Stamp Pack:

Requirement(s)	
ST 0605.4-07	The Precision Time Stamp Pack shall contain the Length (in hex) 0x09.
ST 0605.4-08	The Precision Time Stamp Pack shall contain the Time Status value.
ST 0605.4-09	The Precision Time Stamp Pack shall contain the Precision Time Stamp.

## 9 Nano Precision Time Stamp Pack

The construction of the Nano Precision Time Stamp Pack (shown in Figure 2) includes a Pack Key, its Length and a Value, where the timestamp information is encoded.



**Figure 2: Nano Precision Time Stamp Pack**

The Pack key for the Nano Precision Time Stamp is registered in MISB ST 0807 as:

06.0E.2B.34.02.05.01.01.0E.01.03.03.01.00.00.00 (CRC 51772)

The Length of the pack is 0x09 (9 bytes).

The Value in the pack contains two subfields:

- 3) A one-byte Time Status, which indicates the state of the source time reference (as defined in MISB ST 0603).
- 4) A uint64 (8-byte) Nano Precision Time Stamp (as defined in MISB ST 0603).

## 9.1 Time Status

The Time Status provides information about the timing source reference. See MISB ST 0603 for the definition of this value.

## 9.2 Nano Precision Time Stamp

The Nano Precision Time Stamp is a nanosecond-resolution, 8-byte value as specified in MISB ST 0603. The Nano Precision Time Stamp follows the Time Status value in the pack. Table 2 shows the byte ordering of the Nano Precision Time Stamp, where Byte 1 is the most significant byte.

**Table 2: Byte Assignment for 64-bit Nano Precision Time Stamp**

<b>Bytes 1, 2</b>	Byte 1 and 2 (Most significant bytes) of Nano Precision Time Stamp
<b>Bytes 3, 4</b>	Byte 3 and 4 of Nano Precision Time Stamp
<b>Bytes 5, 6</b>	Byte 5 and 6 of Nano Precision Time Stamp
<b>Bytes 7, 8</b>	Byte 7 and 8 (Least significant bytes) of Nano Precision Time Stamp

The following requirements define the construction rules for the Nano Precision Time Stamp Pack:

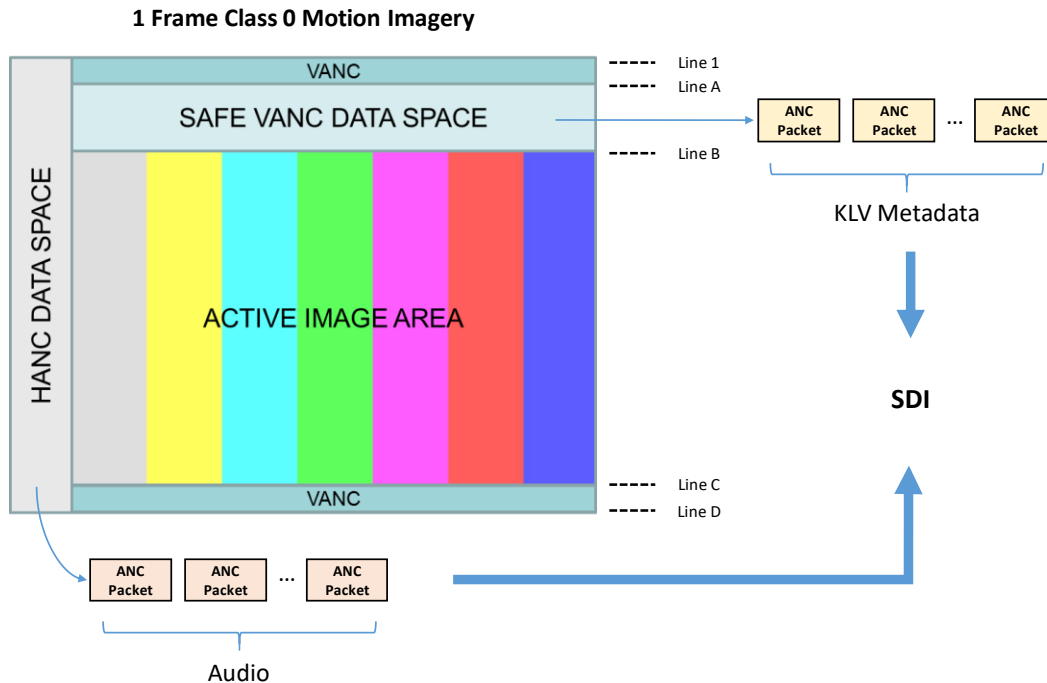
Requirement(s)	
ST 0605.8-20	The Nano Precision Time Stamp Pack shall contain the Length (in hex) 0x09.
ST 0605.8-21	The Nano Precision Time Stamp Pack shall contain the Time Status value.
ST 0605.8-22	The Nano Precision Time Stamp Pack shall contain the Nano Precision Time Stamp.

## 10 Class 0 Motion Imagery

The guidance in this document specifically applies to the set of Class 0 Motion Imagery formats defined by SMPTE standards for enhanced, high and ultra-high definition found in broadcast television. The specific image characteristics for these image formats are further identified in the MISP [3].

### 10.1 Image Format

SMPTE image formats share a common structure as shown in Figure 3.



**Figure 3: General SMPTE Image Format**

Three “data areas” are specified within an image frame: the VANC with a SAFE VANC DATA SPACE sub-region, the HANC DATA SPACE, and the ACTIVE IMAGE AREA. The ACTIVE IMAGE AREA, which extends from the line following Line B through Line C inclusive, contains the imagery content, while the VANC and HANC are reserved for non-image data.

Within the VANC data space, the SAFE VANC DATA SPACE, as defined by the specific format standard is an area considered “safe” for inserting non-image data; this is indicated by Lines A through Line B. SMPTE RP 168 [5] defines a switching point area within the format considered unreliable to insert data. The line designated for the switching point is chosen to be after the vertical synchronization information (to minimize the possibility of disturbances to this information), but early in the vertical interval space. This ensures that data (time information, audio, etc.) transmitted during the VANC remains with the image frame with which it is associated. RP 168 recommends that vital ancillary data or payload data be excluded from the line following the switching line.

Table 3 indicates the values for Line A and Line B which bound the SAFE VANC DATA SPACE for two image formats, as well as the lines designated for timestamps (Precision Time Stamp Pack, Nano Precision Time Stamp Pack and Commercial Time Stamp). The available safe lines per frame within the VANC where metadata and other data can be safely inserted are computed as  $\text{Line B} - \text{Line A} + 1$ .



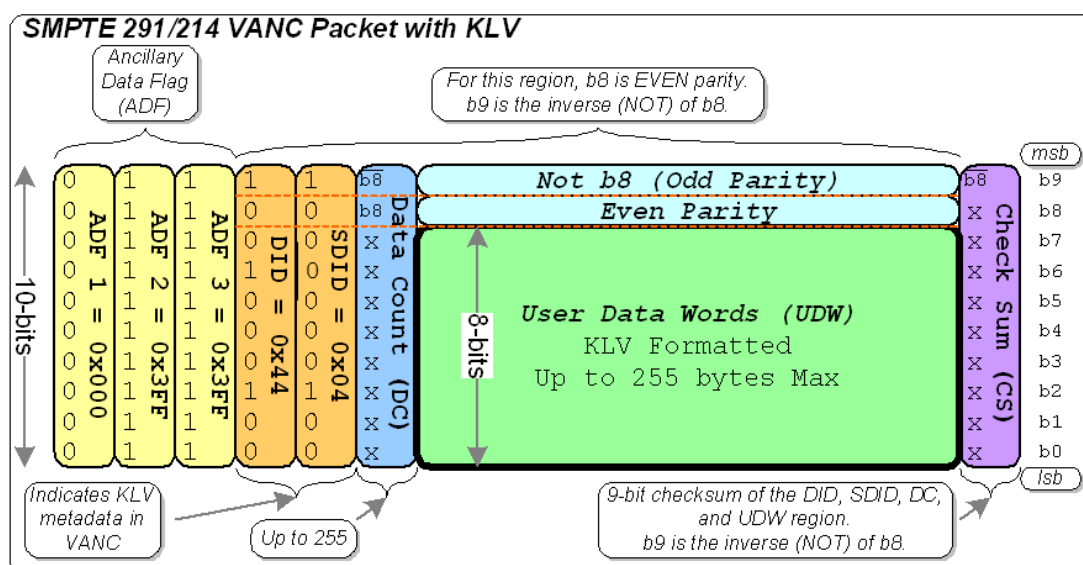
**Table 3: Available Scan Lines for ANC Packets (single link interfaces)**

Image Format	SAFE VANC DATA SPACE		Lines Designated for Timestamps	Available Safe Lines per Frame
	Line A	Line B		
480p	11	39 <sup>1</sup>	Line 9 = Precision Time Stamp Pack or Nano Precision Time Stamp Pack Line 14 = Commercial Time Stamp	29
576p	7	44	Line 9 = Precision Time Stamp Pack or Nano Precision Time Stamp Pack Line 14 = Commercial Time Stamp	38
720p	8	25	Line 9 = Precision Time Stamp Pack or Nano Precision Time Stamp Pack Line 14 = Commercial Time Stamp	18
1080p	8	41	Line 9 = Precision Time Stamp Pack or Nano Precision Time Stamp Pack Line 14 = Commercial Time Stamp	34

<sup>1</sup>The 480p vertical interval persists through Line 42; SMPTE RP 214 [6] recommends a limit of 3 lines earlier.

## 10.2 KLV Metadata

KLV metadata is encapsulated as an ANC packet in primarily the VANC (see Figure 3), and secondarily the HANC. SMPTE ST 291-1 [7] specifies the format for ANC packets inserted into either the VANC or the HANC. An ANC packet begins with a preamble called the Ancillary Data Flag (ADF), which is a three-value 10-bit word sequence of 0x000 (ADF-1), 0x3FF (ADF-2), and 0x3FF (ADF-3) as shown in Figure 4.



**Figure 4: ANC Packet with KLV**

Each ANC packet carries a Type 1 or Type 2 Data Identification (DID) word, which are registered with SMPTE; these signal the type and format of the data contained in the packet. ST 0605 uses SMPTE ST 291-1 Type 2 packets. SMPTE RP 214 [6] defines DID = 0x44 for KLV encoded data, while the Secondary DID word (SDID) signals the use of the VANC (SDID = 0x04) or HANC (SDID = 0x14). The Data Count (DC) represents the number of User Data Words (UDW) in an ANC packet, which has a maximum value of 255.

The DID, SDID, DC, and the UDW's within an ANC packet are 10-bit values. Bit 8 (b8) is used to indicate even parity, while bit 9 (b9) = NOT b8 indicates its inverse.

### 10.2.1 User Data Words (UDW) formatting for KLV data

The UDW space of an ANC packet formatted to carry KLV data is shown in Figure 5. SMPTE RP 214 [6] specifies a method for inserting KLV-formatted data into ANC packets. It describes the packaging of 8-bit data within the 10-bit UDW space of an ANC packet, a Message ID (MID) field, and a Packet Sequence Count (PSC).

The first three words of the UDW space are mandatory per SMPTE RP 214:

- The first word of the UDW space is a Message ID (MID) field, which identifies ANC packets as belonging to the same KLV message.
- The next two words of the UDW space represent a Packet Sequence Counter (PSC), which links long KLV messages to one another.

The 255-3=252 bytes balance are available for KLV data payload within each ANC packet:

- The balance of the UDW space is for KLV data (up to 252 bytes). Over a digital interface, bit 8 of a KLV UDW is the even parity of bits 0 through 7, and bit 9 is the logical NOT of bit 8.

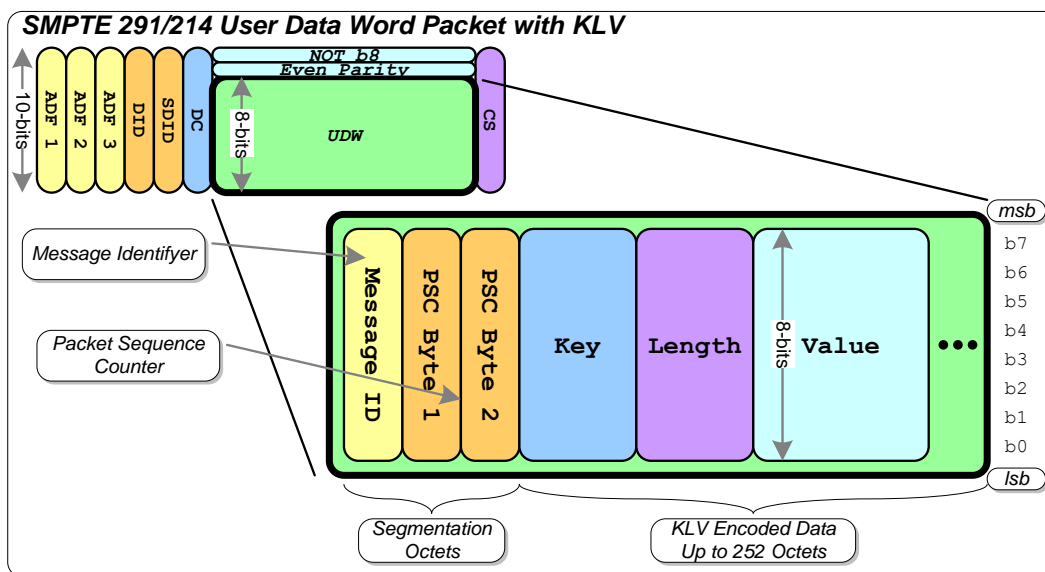


Figure 5: User Data Word space carrying KLV data

Requirement	
ST 0605.4-02	KLV Metadata shall be formatted in accordance with SMPTE RP 214 [6].

### 10.2.1.1 Message ID (MID) Information

In SMPTE RP 214, the MID value identifies ANC packets carrying information belonging to the same KLV encoded message. The MID increments with each different message from one (1) to 255 (zero is not supported) with each KLV message sent within the ANC space.

Note: The initial release of this document (RP 0605 Aug 2006) recommended using the MID field to convey additional information about the type of KLV data contained in the ANC packet. This older method allowed the same MID to be for multiple different KLV packets each falling into a common group (i.e. “Geospatial / Security Data” had a MID of 0x01). When a second KLV packet is identified with the same MID value as a previous packet, the PSC is then repeated. Downstream systems then ignore the second set of KLV packets as they have identical MID and PSC values as previous packets. This practice is no longer recommended (deprecated in RP 0605.2 May 2008).

Requirement	
ST 0605.4-04	The practices for identifying Message ID (MID) values shall be in accordance with SMPTE RP 214 [6].

### 10.2.1.2 Packet Sequence Count (PSC) Information

KLV encoded messages may be comprised of multiple ANC packets. The two UDWs following the MID field represent a packet sequence count (PSC). The PSC – a 16-bit number – indicates the ANC packet for the KLV encoded message. The first data word of the PSC represents the upper 8 bits and the second data word represents the lower 8 bits of the 16-bit number (bit 7 of the first word represents the MSB, while bit 0 of the second word represents the LSB of the PSC value).

The first ANC packet for each different MID has a PSC value starting at one (1) and increments by one (1) for each successive VANC KLV packet carrying a KLV packet. KLV data is removed beginning with the ANC packet with PSC = 1.

## 10.2.2 Inserting the Precision Time Stamp Pack into the VANC

Requirement(s)	
ST 0605.8-23	Where a Precision Time Stamp Pack is used, the Precision Time Stamp Pack shall be present in a SMPTE RP 214 [6] packet in the VANC data space of every Motion Imagery frame.
ST 0605.8-24	Where a Precision Time Stamp Pack is used, the Precision Time Stamp Pack shall be the first ANC packet on Line 9 of the Motion Imagery frame.

As some systems may benefit from additional information on the quality of the timestamp, it is recommended a Time Transfer Local Set, as defined in MISB ST 1603, be inserted following the Precision Time Stamp Pack.

Additional ANC packets may follow the Precision Time Stamp Pack.

### 10.2.3 Inserting the Nano Precision Time Stamp Pack into the VANC

Requirement(s)	
ST 0605.8-25	Where a Nano Precision Time Stamp Pack is used, the Nano Precision Time Stamp Pack shall be present in a SMPTE RP 214 [6] packet in the VANC data space of every Motion Imagery frame.
ST 0605.8-26	Where a Nano Precision Time Stamp Pack is used, the Nano Precision Time Stamp Pack shall be the first ANC packet on Line 9 of the Motion Imagery frame.

Since some systems may benefit from additional information on the quality of the timestamp, it is recommended a Time Transfer Local Set, as defined in MISB ST 1603, be inserted following the Nano Precision Time Stamp Pack.

Additional ANC packets may follow the Nano Precision Time Stamp Pack.

### 10.2.4 Commercial Time Stamp

To improve interoperability with commercial equipment, a Commercial Time Stamp as defined in MISB ST 0603 may be inserted into each Motion Imagery frame. The Commercial Time Stamp is formatted into a SMPTE ST 291-1 ANC packet (called Ancillary Time Code or ATC) per SMPTE ST 12-2 [8].

Requirement(s)	
ST 0605.4-11	When available a Commercial Time Stamp shall be inserted in the VANC of every Motion Imagery frame.
ST 0605.5-16	When present, the Commercial Time Stamp shall be the only ANC packet on Line 14 of the Motion Imagery frame.

It is recommended that no other data be placed onto Line 14 other than the Commercial Time Stamp.

## 10.3 Motion Imagery Payload Identifier

SMPTE ST 424 [9] relies on SMPTE ST 425 [10] for identifying the source image format conveyed over a SDI physical interface. SMPTE ST 425 mandates that a Payload Identifier (specified by SMPTE ST 352 [11]) be included in the HANC.

## 10.4 Guidelines for Data Placement

Image formats allow various color models; for example, a color model based on R'G'B' tristimulus values, or a color model based on Luma and Chroma values (e.g. Y'C<sub>b</sub>C<sub>r</sub>). When using a Luma/Chroma color model, metadata is inserted into the Luma space first followed by use of the Chroma space. For example, Line 9 Luma data, Line 10 Luma data ... Line B Luma data, followed by Line 9 Chroma data, Line 10 Chroma data ... etc.

Requirement(s)	
ST 0605.4-03	The Luma data space within the VANC shall be used for KLV data prior to using the Chroma data space.
ST 0605.4-15	When inserting ANC packets containing non-KLV data into the VANC, those packets shall follow all ANC packets containing KLV data.
ST 0605.5-17	KLV data shall be inserted into the VANC only in the SAFE VANC DATA SPACE as specified in MISB ST 0605 Table 3.

## 10.5 Audio Encoding in AES3

The HANC is principally used to carry digital audio. SMPTE ST 299-1 [12] (16 audio channels) and SMPTE ST 229-2 [13] (32 audio channels) defines the mapping of 24-bit AES3 (Digital Audio Interface Format) digital audio data into the ancillary data space as ANC packets. The formatting of non-PCM audio and other data, such as metadata, to AES3 is defined by SMPTE ST 355 [14], SMPTE ST 337 [15], and SMPTE ST 339 [16].

Note: Although some legacy systems used the HANC to carry metadata, it is recommended that no metadata be inserted into the HANC.

Audio carriage in SDI is well described in these standards, so no further information is provided here.

Requirement	
ST 0605.5-18	KLV data encapsulated in an AES3 serial digital audio stream shall comply with SMPTE ST 299-1 [12] and SMPTE ST 299-2 [13] with data formatted according to SMPTE ST 355 [14], SMPTE ST 337 [15] and SMPTE ST 339 [16].

## 11 SDI Standards: Formats/Interfaces

The SMPTE standards for various Image Formats and the supporting SDI standard(s) are listed in Table 4. Also, shown is the number of Active Pixels per Line, Active Lines per Frame and the supported Frame Rate(s). Note that only common frame rates are listed. Please consult the relevant standard for a complete list of supported frame rates. The designations in the Format Standard column following the reference for 3G/6G/12G indicate the following: “S” = Single-Link, “D” = Dual-Link, “Q” = Quad-Link SDI. Appendix C provides additional information on the decomposition of an image source into multiple links.

SMPTE continues to develop SDI standards which support greater data throughputs, for example, 24G SDI and varieties of optical SDI interfaces. When standardized these will be included as candidate interfaces.

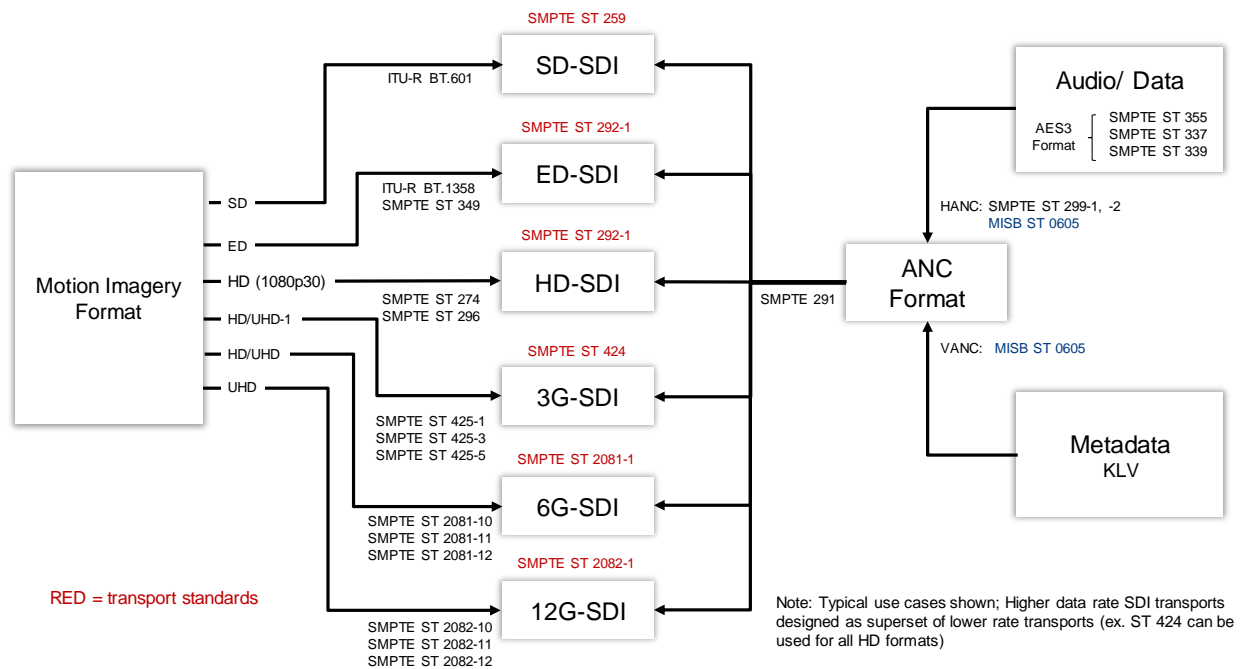
**Table 4: Image Format Standards and Companion SDI Standards**

Image Format	Format Standard	SDI Standard	Active Pixels per Line	Active Lines per Frame	Frame Rate	Aspect Ratio
Enhanced Definition (progressive line Standard Definition)						
480p	SMPTE ST 267 [17] SMPTE ST 294 [18]	SMPTE ST 259 [19] (Level D 4:2:0)	720	483	60M <sup>2</sup>	4:3, 16:9
480p	SMPTE ST 293 [20]	SMPTE ST 349 [21] SMPTE ST 292-1 [22]	720	483	60M/30M	
576p	ITU-R BT.1358 [23]	SMPTE ST 349 [21] SMPTE ST 292-1 [22]	720	576	50/25	
High Definition (HD-SDI)						
720p	SMPTE ST 296 [24]	SMPTE ST 292-1 [22]	1280	720	60/50/30/25	16:9
1080p	SMPTE ST 274 [25]		1920	1080	30/25	
HD/UHD-1 10-bit 4:2:0 (3G-SDI)						
1080p	SMPTE ST 425-1 [10] S	SMPTE ST 424 [9]	1920	1080	60	16:9
2160p	SMPTE ST 425-5 [26] Q	SMPTE ST 424 [9]	3840	2160	60	16:9
	SMPTE ST 425-3 [27] D	SMPTE ST 424 [9]			30/25	16:9
HD/UHD-1/UHD-2 10-bit 4:2:0 (6G-SDI)						
1080p	SMPTE ST 2081-10 [28] S	SMPTE ST 2081-1 [29]	1920	1080	120	16:9
2160p	SMPTE ST 2081-11 [30] D	SMPTE ST 2081-1 [29]	3840	2160	60	16:9
	SMPTE ST 2081-10 [28] S	SMPTE ST 2081-1 [29]			30/25	
4320p	SMPTE ST 2081-12 [31] Q	SMPTE ST 2081-1 [29]	3840	2160	30/25	16:9
UHD-1/UHD-2 10-bit 4:2:0 (12G-SDI)						
2160p	SMPTE ST 2082-10 [32] S	SMPTE ST 2082-1 [33]	3840	2160	60	16:9
4320p	SMPTE ST 2082-12 [34] Q	SMPTE ST 2082-1 [33]	7680	4320	60	16:9
	SMPTE ST 2082-11 [35] D	SMPTE ST 2082-1 [33]			30/25	

UHD-1 (10G-SDI optical)						
2160p	SMPTE ST 435-1 [36]	SMPTE ST 435-2 [37]	3840	2160	30/25	16:9
<sup>2</sup> M = 1000/1001						

Figure 6 pictorially shows a subset from the family of SDI Containers along with corresponding supporting standards which define how Motion Imagery, Audio and Metadata for each are formatted. The SDI standards were designed hierarchically, where higher capacity transports support increased pixel density and frame rate, also support the lower capacity formats. This allows one transport to support lower capacity formats.

Standards SMPTE ST 355 [14], SMPTE ST 337 [15] and SMPTE ST 339 [16] support the formatting of digital audio and data into the AES3 [30] format, while SMPTE ST 299-1 [12] and SMPTE ST 299-2 [13] define the mapping from AES3 into HD-SDI and 3G-SDI formats respectively.



**Figure 6: Subset of SDI Containers and Format Standards**

Guidance for mapping infrared Motion Imagery into SDI is provided in MISB ST 0403 [38].

Requirement	
ST 0605.9-27	The mapping of digital infrared Class 0 Motion Imagery into a SMPTE ST 292-1 [22] interface shall be defined by MISB ST 0403 [38].

## 12 Deprecated Requirements

Requirement(s)	
ST 0605.4-01 (Deprecated)	The Precision Time Stamp, Commercial Time Stamp and KLV Metadata shall be inserted into the Vertical Ancillary Data Space (VANC). [Redundant: covered by REQ's 5 & 11]
ST 0605.4-05 (Deprecated)	A Precision Time Stamp Pack representing Coordinated Universal Time (UTC) for the start of a Motion Imagery frame shall be present in a SMPTE RP 214 [6] packet in the VANC data space of every Motion Imagery frame. [Precision Time Stamp based on count since Epoch, not UTC]
ST 0605.4-06 (Deprecated)	The Precision Time Stamp Pack shall contain the Key (in hex) 06.0E.2B.34.02.05.01.01.0E.01.01.03.11.00.00.00 (CRC 23259). [defined in ST 0807, so no requirement necessary]
ST 0605.4-12 (Deprecated)	When present, the Commercial Time Stamp shall be the first SMPTE ST 291-1 [7] packet on Line 14 of the Motion Imagery frame. [changed "first" to "only" as recommended by SMPTE]
ST 0605.4-13 (Deprecated)	KLV data shall be allowed to be inserted into the VANC on Line 15 and above. Non-KLV data is allowed on line 14 after the Commercial Time Stamp. [VANC is not limited to KLV; non-image data allowed in safe VANC data space]
ST 0605.4-14 (Deprecated)	The insertion of KLV data in a frame shall discontinue once the end of the VANC is reached [states an obvious fact and should not be a requirement]
ST 0605.7-19 (Deprecated)	A Precision Time Stamp Pack shall be present in a SMPTE RP 214 [6] packet in the VANC data space of every Motion Imagery frame.
ST 0605.4-10 (Deprecated)	The Precision Time Stamp Pack shall be the first SMPTE ST 291-1 [7] ANC packet on Line 9 of the Motion Imagery frame.



## 13 Appendix A: Example VANC Capacities – *Informative*

The following calculations approximate the VANC capacity for various digital image formats.

SMPTE ST 291-1 [7] specifies the format of an ANC packet. A packet contains 10-bytes of overhead (3-bytes ADF, 1-byte DID, 1-byte SDID, 1-byte DC, 1-byte MID, 2-byte PSC, 1-byte CS) with a maximum of 252 bytes available for data. Thus, each ANC packet has a maximum of 262 bytes. Metadata capacity calculated for Extended Definition 480p, 576p, and High Definition 720p, 1080p systems is shown in Table 5. For each Image Format, the number of ANC Packets (full) per VANC Line along with the VANC Safe Lines provides the number of Bytes per Frame, which corresponds to a computed Data Rate for 60 Frames per Second (FPS).

**Table 5: VANC Capacity for Full ANC Packets**

Image Format	Samples per Line	ANC Packets (full) per VANC Line	VANC Safe Lines <sup>3</sup> (Table 3)	Bytes per Frame	Data Rate (60 FPS) (Mbps)
480p	720	2	58	29,232	14.03
576p	720	2	76	38,304	18.38
720p	1280	4	36	36,288	17.41
1080p	1920	7	68	119,952	57.57
<sup>3</sup> Assuming an equal number of lines for Luma and Chroma the number of VANC Safe Lines is twice that specified in Table 3.					

A full ANC packet can contain 262 bytes. The maximum number of ANC packets when full per VANC Line is computed by the number of Samples per Line divided by 262 bytes. From Table 3, and assuming a color model of 4:2:2, the Bytes per Frame is the product of the number of ANC Packets times the number of VANC Safe Lines times 262 bytes. Data Rate, expressed in megabits per second, for 60 frames per second (FPS) is then the number of Bytes per Frame times 8 bits per Byte times 60 FPS.

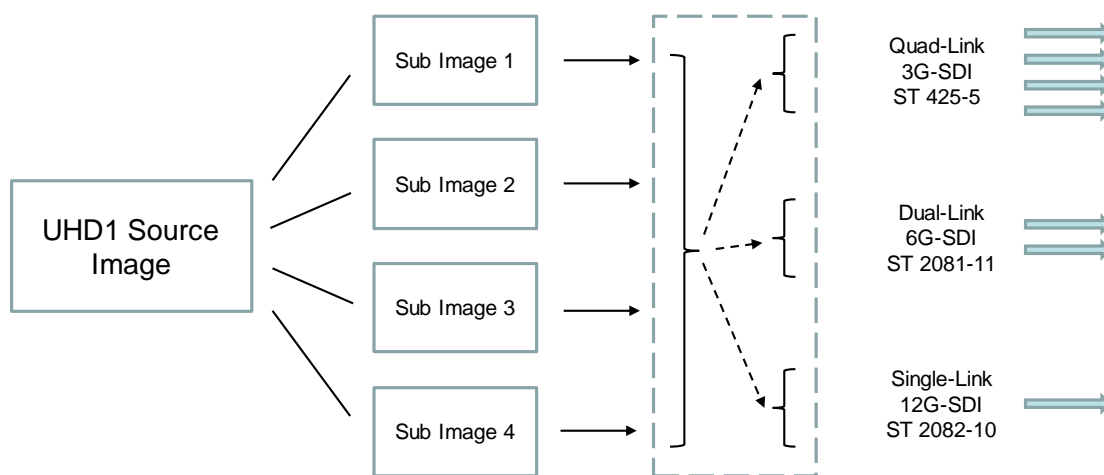
These calculations ignore partial packets, which would increase the data rate, and do not account for the requirements on Lines 9 and 14 indicated in this document.

## 14 Appendix B: Ultra-High Definition Mapping – *Informative*

For UHD the mapping of ancillary data into 3G-SDI, 6G-SDI and 12G-SDI follow the guidelines for 1080p, which prescribes a decomposition of UHD into sub-images equivalent to 1080p. UHD1 is characterized as “4K” imagery, while UHD-2 is characterized as “8K” imagery. The current roadmap for UHD, which includes UHD-1 and UHD-2, divides a UHD image into multiple HD (1080p) sub-images – 4 for UHD-1 and 16 for UHD-2. Each sub-image has timing, audio, and data, etc. added like HD. The sub-images are then multiplexed as necessary for transport.

Like other formats UHD comes in a variety of image formats supporting numerous image rates, pixel bit depths, and color sampling models. The type of SDI is based on the election of these format choices. For example, a UHD-1 format of 3840x2160p30 4:2:2 10 bits produces approximately 5 Gbps, which requires either a dual-link 3G-SDI or a single-link 6G-SDI link. Stepping up the image rate to 60 Images per second produces approximately 10 Gbps, thus indicating a quad-link 3G-SDI, a dual-link 6G-SDI, or a single-link 12G-SDI.

For UHD-1, the sub-images are combined into a single-link 12G-SDI (SMPTE ST 2082-10) dual-link 6G-SDI (SMPTE ST 2081-11), or quad-link 3G-SDI (SMPTE ST 425-5) for transport as shown in Figure 7. Payload identifiers are required to indicate the specific 1080p component image. 1080p components are mapped as channels (i.e. CH1 - CH8). SMPTE requires that ANC data be mapped into CH1. ANC data inserted into the VANC follows the same rules as the 1080p format.



**Figure 7: UHD 1 Transport over 3G/6G/12G SDI**

For 8K UHD-2 a dual-link 12G-SDI interface is needed to support 7680x4320p30 4:2:2 10-bits, while a quad-link 12G-SDI is necessary for an image rate of 60 Images per second.

Please consult the SMPTE documentation for further guidance on SDI standards for a given application.